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Developing the mechatronics and robotics at Nizhny Tagil Technological Institute of Ural Federal University

V V Goman, S A Fedoreev

Ural Federal University, 622031, Nizhny Tagil, Krasnogvardeyskaya str, 59, Russia, vvg_electro@hotmail.com

Abstracts. This report concerns the development trends of education in the field of the Mechatronics and Robotics at Nizhny Tagil Technological Institute (branch of Ural Federal University). The paper considers new teaching technologies, experience in upgrade of the laboratory facilities and some results of development Mechatronics and Robotics educational courses.

1. Introduction

In 2017, Nizhny Tagil Technological Institute (NTI), a branch of Ural Federal University (UrFU), graduated its first bachelors in Mechatronics and Robotics. This new and complicated professional qualification has been mastered due to the cooperated effort of multiple chairs, due to advanced training of the professors, new teaching technologies, and development and upgrade of the laboratory facilities.

2. Development of laboratory facilities

At the outset, the institute was equipped with a number of training laboratories that enabled teaching of some subjects of this discipline. However, the laboratory equipment was partly obsolete and dispersed among different buildings. It needed to be replenished and consolidated by a single concept of mechatronics.

To this end, the hydraulics and pneumatics laboratory [1] - the most advanced and spacious one - got new electric drives, an automation system, and an industrial data transmission network. This network (powered by Siemens equipment) united the available laboratory benches of different operation principles into a single mechatronic system.

The laboratory has contributed to the training of students and retrainees and thus improved the quality of training in industrial automation and mechatronics (that included programming of Siemens controllers, industrial information networks, visualization system, electric and hydraulic drives etc.). Besides students specialized in Mechatronics and Robotics, the laboratory has been of great use for the students of Design and Technology Supports of Engineering Works; students of numerous technical professions have been studying Electronics, Automation of Production Processes, Control Systems, Electric Drives and other disciplines there. The laboratory is being used in such projects as New Staff for Defense Industry Complex, and training in the System Engineering course for the Higher Engineering School of UrFU.

For this reason, the laboratory now features workbenches with electric, hydraulic and pneumatic drives, automation equipment (programmable logical controllers - PLC and accessories), personal computers, human-machine interface (HMI) devices, and integrated industrial data transmission networks (Profibus and Profinet).

Figure 1. S7-300 PLC-based workbench

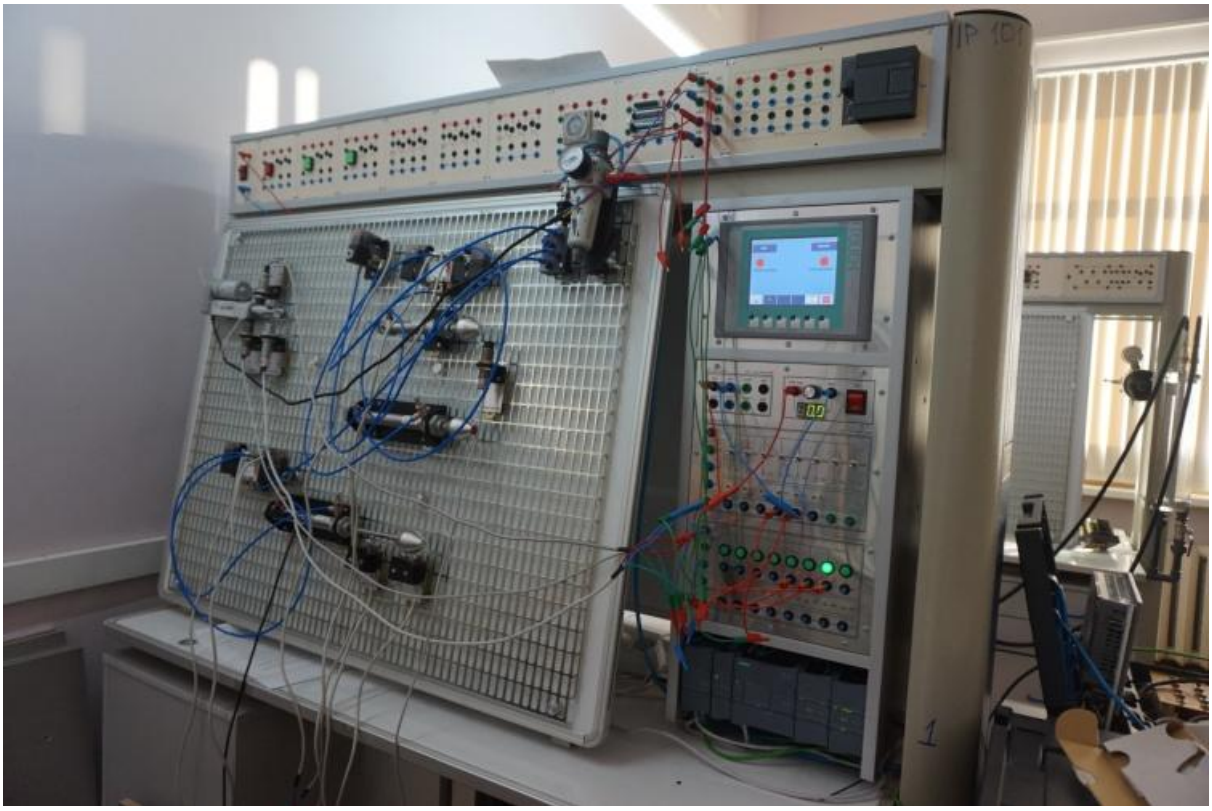

Figure 2. S7-1200 PLC-based workbench

Figure 1 shows a typical PLC-based training workbench. This workbench includes the Siemens PLC S7-300 [2]. S7-300 is widely used in industry for medium complexity automation tasks. In figure 2, you see a S7-1200 PLC-based laboratory workbench for training in pneumatic drive and pneumatic automatics. S7-1200 [3] is PLC for small and medium automation systems. Figure 3 gives training laboratory workbench based on Sinamics electric drives.

All the PLCs, PCs and operator panels are united with a single data transmission network to simplify the interaction between students and professors and enable study of various industrial data transmission networks and fieldbus networks.

The laboratory also features:

1. PLC-equipped workbenches imitating workshop mechanisms (turn table, distribution system, pump station, electric heating station, positioning system);
2. educational robotics construction kits based on Arduino microcontrollers, used for practical trainings and lessons of the robotics section for school students;
3. a CNC milling machine by Purelogic, 3D-printer;
4. a virtual hands-on course allowing remote operation of a real PLC with virtual controlled objects (figure 4) [4, 5, 6];
5. a software package.

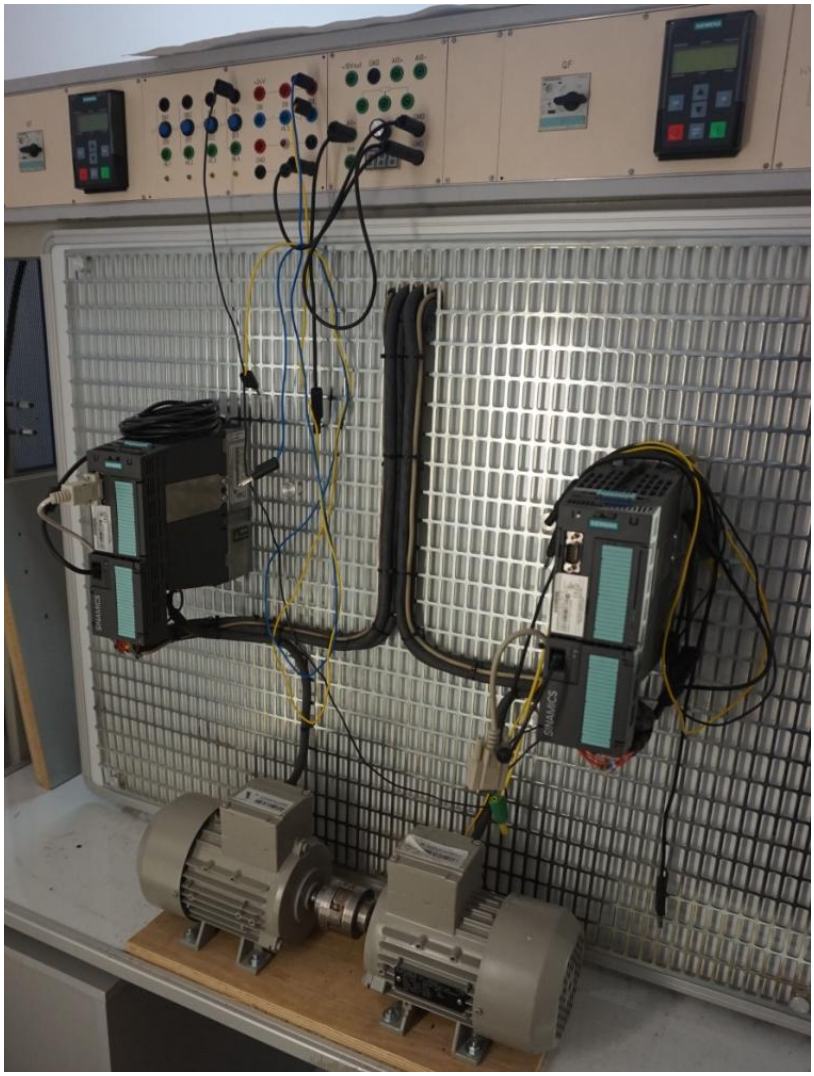

Figure 3. A workbench based on electric drives by Sinamics

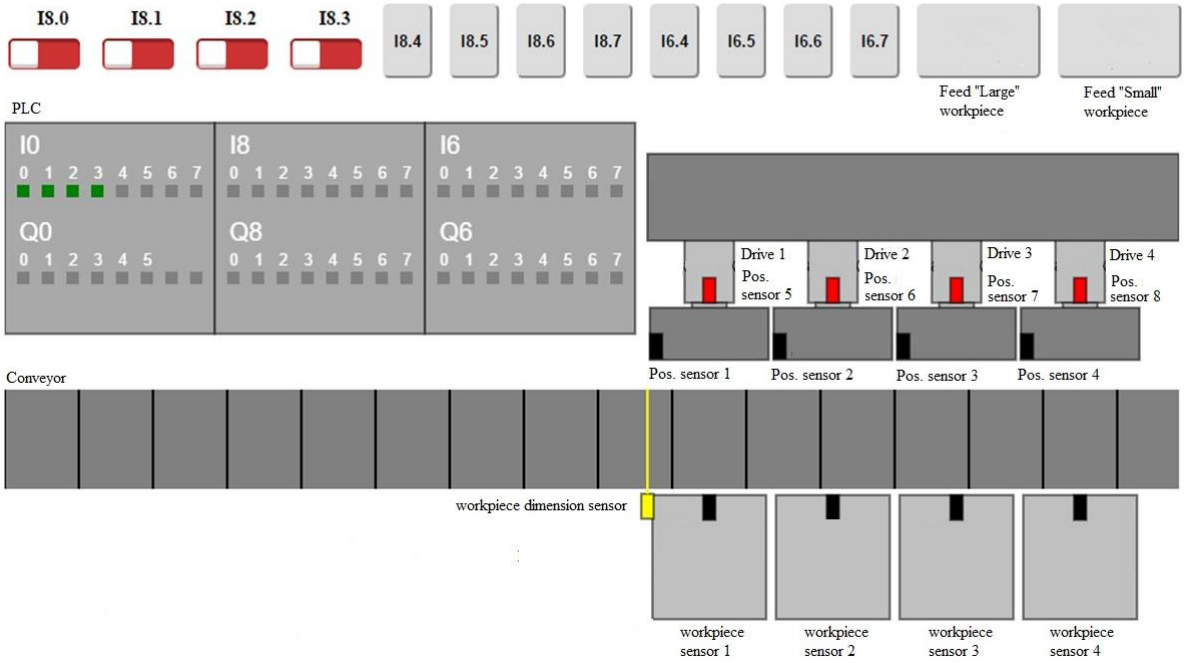

Figure 4. Virtual lab workbench: Sorting Conveyer

Also we can use the equipment of our industrial partners (EVRAZ and Uralvagonzavod) - Festo MPS (modular production system) and MTLR (production line with turning and milling CNC-machines and robot on linear axis) systems.

3. Education technologies

The courses apply the world's best practices of engineering education including, first of all, CDIO initiative (Conceive – Design – Implement – Operate) [7] by Massachusetts Institute of Technology (also referred to as Project-Based Learning). Today, this project unites over 100 universities all over the world, including a number of Russian institutes, with Ural Federal University among them.

Project practices for bachelors are moderated by project engineers – postgraduate students chosen from the most talented bachelors (simultaneously, they are being involved in developing real projects).

The general supervision and goal-setting are provided by profession supervisors: chair professors, educational program leaders. When necessary, the courses apply to competent experts, consultants, and plant employees. Different professions are consolidated by a multidisciplinary Students' Design Bureau, which residents being guided by their supervisors and experts are able to work through a certain idea, provide project docs and calculations to finally implement it as a real product or technology (figure 5).

As new projects keep evolving into real products, we are intended to take part in programs of Strategic Initiative Agency (National Technology Initiative), Foundation of Innovation Promotion (UMNIK, START, and Commercialization programs). The goal is to establish small innovative businesses (start-ups, spin-off companies with participation of UrFU).

According to this strategy, start-ups, along with big corporate customers, are to generate tasks for students' project activities.

Looking at the first graduation of the Mechatronics and Robotics qualification, we can confidently state that the efforts have yielded some results. For most graduates, their final qualification work is intermediate stage of work over their project. Three project concepts have been supported by the Foundation of Innovation Promotion (UMNIK and START programs). They are a mechanic therapy tool to recover limbs after injuries and treat cerebral palsy, an innovative machine for protective

coating of electric contacts (dozen times more effective than manual application); a robotic machine for electrosparking application of coating in hard-to-reach locations such as inside of pipes. Some final qualification works 2017 has developed training laboratory workbenches showing positioning systems, electric drive machine-tools, and electric-heat control systems.

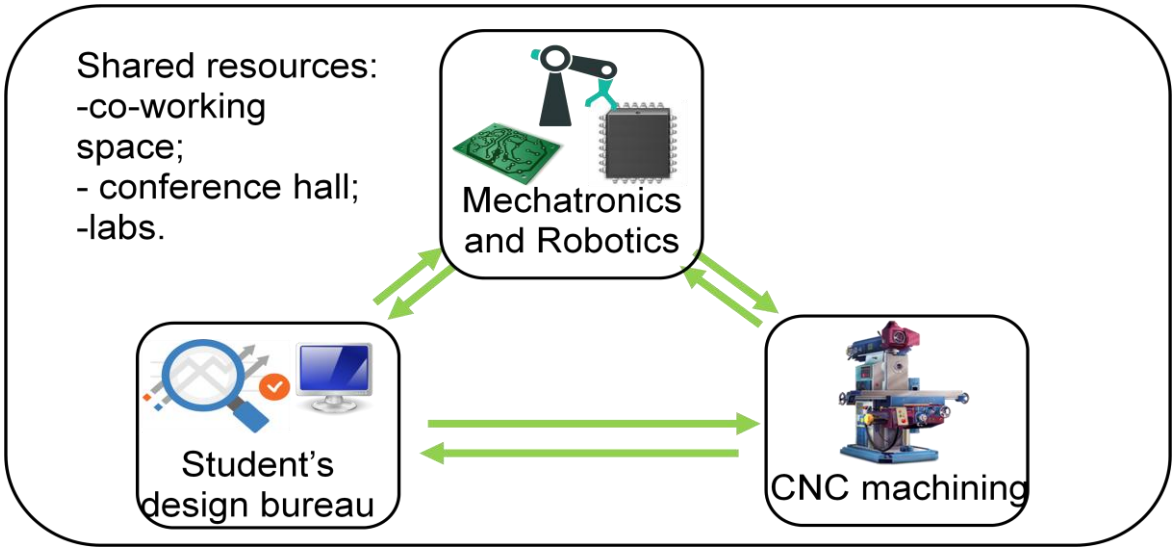

Figure 5. Interactions within Project Learning

4.Plans and prospects

We plan to focus on such disciplines as artificial intelligence, machine learning, industrial robotics, and system engineering. To train practical skills, we are training student teams to participate in WorldSkills interuniversity championships. A license for master degree education program has been obtained.

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